GEOPHEX, LTD. – EM GEM-5 SINGLE SENSOR/MAN-PORTABLE

BLIND GRID SCORING RECORD NO. 694

The EM GEM-5 Single Sensor
in the man-portable platform
is shown as demonstrated
by Geophex, Ltd.

The EM GEM-5 Single Sensor in the man-portable platform was demonstrated by Geophex, Ltd. at the Aberdeen Proving Ground Standardized Demonstration Site's Blind Grid Area. This technical paper contains the results of that demonstration. This is a reference document only and does not serve as an endorsement of the demonstrator's product by the US Army or the Standardized UXO Technology Sites Program.

For more information

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Technologies under development for the detection and discrimination of unexploded ordnance (UXO) require testing so that their performance can be characterized. To that end, Standardized Test Sites have been developed at Aberdeen Proving Ground (APG), Maryland and Yuma Proving Ground (YPG), Arizona. These test sites provide a diversity of geology, climate, terrain, and weather as well as diversity in ordnance and clutter. Testing at these sites is independently administered and analyzed by the government for the purposes of characterizing technologies, tracking performance with system development, comparing performance of different systems, and comparing performance in different environments.

The Standardized UXO Technology Demonstration Site Program is a multi-agency program spearheaded by the U.S. Army Environmental Center (USAEC). The U.S. Army Aberdeen Test Center (ATC) and the U.S. Army Corps of Engineers Engineering Research and Development Center (ERDC) provide programmatic support. The program is being funded and supported by the Environmental Security Technology Certification Program (ESTCP), the Strategic Environmental Research and Development Program (SERDP) and the Army Environmental Quality Technology Program (EQT).

DEMONSTRATOR'S SYSTEM AND DATA PROCESSING DESCRIPTION

The GEM-5 sensor consists of a coaxial sensing coil set having a central transmitting coil (Tx), two symmetric receiver (Rx) coils wired in a differential mode (Rx), and an electronic console for real-time data processing designed for the next generation GEM-3. The digital signal processor (DSP) performs the transmitter waveform generation and processes samples from the receiver analog-to-digital converter (ADC), including discrete Fourier transform (DFT) math to produce inphase and quadrature at each frequency and data time-stamping with a real-time clock for synchronization to a Differential Global Positioning System (DGPS). Major features of the GEM-5 sensor include: high transmitter moment (48V/40A high-power option), ADC sampling at 192 kHz at 24 bits, sampling at 30 times a second regardless of how many frequencies are used, Integration with an iPAC® hand-held computer for user interface, and iPAC® software with graphical/audio functions and real-time detection and discrimination algorithms.

A schematic comparison of the GEM-3 concentric-coil and the GEM-5 coaxial coil configurations shows the different primary-field bucking schemes. The GEM-3 uses a Tx bucking method via magnetic cavity around the single Rx, whereas the GEM-5 uses an Rx bucking scheme with symmetric Rx coils wired differentially.

The advantage of the coaxial coil configuration (referred to as the GEM-5) over the coplanar-concentric GEM-3 sensor stems from the balanced receiver coils that suppress both noise induced by angular motion in the earth's magnetic field and ambient far-field EM noise (i.e. sferics and geo-magnetic storms). The disadvantage is the increased distance between transmitter coil and target, reducing the primary excitation field.

PERFORMANCE SUMMARY

Results for the Blind Grid test, broken out by size, depth and nonstandard ordnance, are presented below. Results by size and depth include both standard and nonstandard ordnance. The results by size show how well the demonstrator did at detecting/discriminating ordnance of a certain caliber range. The results are relative to the number of ordnances emplaced. Depth is measured from the geometric center of anomalies.

The Response Stage results are derived from the list of anomalies above the demonstrator-provided noise level. The results for the Discrimination Stage are derived from the demonstrator's recommended threshold for optimizing UXO field cleanup by minimizing false digs and maximizing ordnance recovery. The lower 90-percent confidence limit on probability of detection and probability of false positive was calculated assuming that the number of detections and false positives are binomially distributed random variables. All results have been rounded to protect the ground truth. However, lower confidence limits were calculated using actual results.

The overall ground truth is composed of ferrous and non-ferrous anomalies. Due to limitations of the magnetometer, the non-ferrous items cannot be detected. Therefore, the summary presented in the Ferrous Only table exhibits results based on the subset of the ground truth that is solely the ferrous anomalies. The second table exhibits results based on the full ground truth. The response stage noise level and recommended discrimination stage threshold values are provided by the demonstrator.

SUMMARY OF BLIND GRID RESULTS FOR THE GEM-5/MAN-PORTABLE

Metric	Overall	Standard	Nonstandard	By Size			By Depth, m		
				Small	Medium	Large	< 0.3	0.3 to <1	>= 1
RESPONSE STAGE									
P_d	0.70	0.75	0.65	0.65	0.65	1.00	0.85	0.60	0.55
P_d Low 90% Conf	0.63	0.63	0.54	0.57	0.51	0.79	0.75	0.48	0.38
P_d Upper 90% Conf	0.76	0.81	0.76	0.77	0.75	1.00	0.93	0.71	0.74
P_{fp}	0.75	-	-	-	-	-	0.75	0.75	0.65
P_{fp} Low 90% Conf	0.67	-	-	-	-	-	0.63	0.64	0.33
P_{fp} Upper 90% Conf	0.79	-	-	-	-	-	0.83	0.82	0.91
P_{ba}	0.30	-	-	-	-	-	-	-	-
DISCRIMINATION STAGE									
P_d	0.50	0.45	0.55	0.50	0.45	0.70	0.65	0.40	0.40
P_d Low 90% Conf	0.43	0.35	0.45	0.38	0.33	0.45	0.54	0.29	0.21
P_d Upper 90% Conf	0.57	0.55	0.69	0.60	0.58	0.88	0.76	0.52	0.57
P_{fp}	0.50	-	-	-	-	-	0.55	0.50	0.35
P_{fp} Low 90% Conf	0.45	-	-	-	-	-	0.46	0.40	0.09
P_{fp} Upper 90% Conf	0.59	-	-	-	-	-	0.68	0.60	0.67
P_{ba}	0.15	-	-	-	-	-	-	-	-

Response Stage Noise Level: 40.00
Recommended Discrimination Stage Threshold: 5.10

Note: The recommended discrimination stage threshold values are provided by the demonstrator.